

CLAIMS

- 5 1. A process for hydrogenating one or more benzenepolycarboxylic acids or one or more derivatives thereof, or a mixture of one or more benzenepolycarboxylic acids or one or more derivatives thereof by bringing the benzenepolycarboxylic acid or the derivative thereof or the mixture into contact with a hydrogen-containing gas in the presence of a catalyst, said catalyst comprising one or more catalytically active metals applied to a catalyst support comprising one or more ordered mesoporous materials.
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- 15 2. A process as claimed in claim 1 wherein the catalyst support further comprises one or more macroporous materials combined in admixture with the one or more ordered mesoporous materials.
- 20 3. A process as claimed in claim 1 wherein the catalyst support further comprises one or more mixed porosity materials combined in admixture with the one or more ordered mesoporous materials.
- 25 4. A process as claimed in claim 3 wherein the mixed porosity material contains mesopores and macropores.
5. A process as claimed in any one of claims 2 to 4 wherein the macroporous or mixed porosity materials are amorphous.
- 30 6. A process as claimed in any one of claims 2 to 5 wherein at least one of the macroporous or mixed porosity materials is alumina.
7. A process as claimed in any one of the preceding claims wherein at least one of the ordered mesoporous materials is ordered mesoporous silica.

8. A process as claimed in any one of the preceding claims wherein at least one of the ordered mesoporous materials is a material that is synthesized using amphiphilic compounds as directing agents.

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9. A process as claimed in claim 8 wherein one or more of the ordered mesoporous materials is selected from the group consisting of materials designated as SBA (Santa Barbara) such as SBA-2, SBA-15 and SBA-16, materials designated as FSM (Folding Sheet Mechanism) such as FSM-16 and KSW-2, materials designated as MSU (Michigan State) such as MSU-S and MSU-X, materials designated as TMS or Transition Metal Sieves, materials designated as FMMS or Functionalised Monolayers on Mesoporous Supports or materials designated as APM or Acid Prepared Mesostructure or ordered mesoporous materials designated as M41S.

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10. A process as claimed in claim 9 wherein the one or more ordered mesoporous materials designated as M41S are selected from the group consisting of MCM-41, MCM-48 and MCM-50.

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11. A process as claimed in claim 10 wherein the ordered mesoporous material is MCM-41.

12. A process as claimed in any one of the preceding claims wherein the one or more catalytically active metals are one or more metals selected from transition group VIII of the Periodic Table.

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13. A process as claimed in any one of the preceding claims wherein the one or more catalytically active metals are selected from the group consisting of platinum, rhodium, palladium, cobalt, nickel or ruthenium or a mixture of two or more thereof.

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14. A process as claimed in any one of the preceding claims wherein the one or more catalytically active metals are selected from the group consisting of platinum, palladium, or ruthenium or a mixture of two or more thereof.
- 5 15. A process as claimed in any one of the preceding claims wherein the one or more catalytically active metals are a mixture of platinum and palladium.
- 10 16. A process as claimed in any one of claims 1 to 11 wherein the catalytically active metal is ruthenium.
- 15 17. A process as claimed in any one of the preceding claims wherein the one or more catalytically active metals comprise one or more metals of transition group I or VII of the Periodic Table.
18. A process as claimed in any one of the preceding claims wherein the one or more catalytically active metals are present in an amount of from 0.01 to 30% by weight, based on the total weight of the catalyst.
- 20 19. A process as claimed in any one of claims 2 to 15 wherein the one or more macroporous materials have a BET surface area of at most 30 m²/g.
- 25 20. A process as claimed in any one of the preceding claims wherein the one or more mesoporous materials have a BET surface of greater than 600 m²/g.
- 30 21. A process as claimed in any one of claims 1 to 19 wherein the one or more mesoporous materials have a BET surface area of greater than 1000 m²/g.

22. A process as claimed in any one of claims 1 to 21 wherein the metal surface area on the catalyst is from 0.01 to 10 m²/g of the catalyst.
- 5 23. A process as claimed in any one of claims 1 to 21 wherein the metal surface are on the catalyst is from 0.05 to 5 m²/g of the catalyst.
24. A process as claimed in any one of claims 1 to 21 wherein the metal surface are on the catalyst is from 0.05 to 3 m²/g of the catalyst.
- 10 25. A process as claimed in any one of claims 1 to 24 wherein the hydrogenation catalyst has a metal dispersion value relating to the strongly chemisorbed component in excess of 20%.
- 15 26. A process as claimed in any one of claims 1 to 24 wherein the hydrogenation catalyst has a metal dispersion value relating to the strongly chemisorbed component in excess of 25%.
- 20 27. A process as claimed in any one of claims 1 to 24 wherein the hydrogenation catalyst has a metal dispersion value relating to the strongly chemisorbed component in excess of 30%.
- 25 28. A process as claimed in any one of claims 1 to 27 wherein the hydrogenation catalyst has a total metal dispersion values in excess of 45%.
29. A process as claimed in any one of claims 1 to 27 wherein the hydrogenation catalyst has a total metal dispersion values in excess of 50%.

30. A process as claimed in any one of claims 1 to 27 wherein the hydrogenation catalyst has a total metal dispersion values in excess of 55%.
- 5 31. A process as claimed in any one of the preceding claims wherein the one or more benzenepolycarboxylic acids is selected from the group consisting of phthalic acid, terephthalic acid, isophthalic acid, trimellitic acid, trimesic acid, hemimellitic acid and pyromellitic acid and mixtures of two or more thereof.
- 10 32. A process as claimed in any one of claims 1 to 30, wherein the one or more benzenepolycarboxylic acid derivatives are selected from the group consisting of monoalkyl and dialkyl esters of phthalic acid, terephthalic acid and isophthalic acid, monoalkyl, dialkyl and trialkyl esters of
- 15 trimellitic acid, trimesic acid and hemimellitic acid, monoalkyl, dialkyl, trialkyl and tetraalkyl esters of pyromellitic acid, anhydrides of phthalic acid, trimellitic acid and hemimellitic acid, pyromellitic dianhydride and mixtures of two or more thereof
- 20 33. A process as claimed in claim 32 wherein the alkyl groups are linear or branched and each group has from 1 to 30 carbon atoms.
34. A process as claimed in claim 32 wherein the alkyl groups are linear or branched and each group has from 2 to 20 carbon atoms.
- 25 35. A process as claimed in claim 32 wherein the alkyl groups are linear or branched and each group has from 3 to 18 carbon atoms.
- 30 36. A process as claimed in any one of claims 1 to 30 wherein the one or more benzenecarboxylic acid derivates are one or more phthalates or isophthalates selected from the group consisting of monomethyl phthalate,

dimethyl phthalate, diethyl phthalate, di-n-propyl phthalate, di-n-butyl
 phthalate, di-tert-butyl phthalate, diisobutyl phthalate, monoglycol esters
 of phthalic acid, diglycol esters of phthalic acid, di-n-octyl phthalate,
 diisooctyl phthalate, di-2-ethylhexyl phthalate, di-n-nonyl phthalate,
 diisononyl phthalate, di-n-decyl phthalate, diisodecyl phthalate, di-n-
 undecyl phthalate, diisoundecyl phthalate, diisododecyl phthalate, di-n-
 octadecyl phthalate, diisooctadecyl phthalate, di-n-eicosyl phthalate,
 monocyclohexyl phthalate, dicyclohexyl phthalate; alkyl isophthalates
 such as monomethyl isophthalate, dimethyl isophthalate, diethyl
 isophthalate, di-n-propyl isophthalate, di-n-butyl isophthalate, di-tert-
 butyl isophthalate, diisobutyl isophthalate, monoglycol esters of
 isophthalic acid, diglycol esters of isophthalic acid, di-n-octyl
 isophthalate, diisooctyl isophthalate, di-2-ethylhexyl isophthalate, di-n-
 nonyl isophthalate, diisononyl isophthalate, di-n-decyl isophthalate,
 diisodecyl isophthalate, di-n-undecyl isophthalate, di-isoundecyl
 isophthalate, diisododecyl isophthalate, di-n-octadecyl isophthalate,
 diisooctadecyl isophthalate, di-n-eicosyl isophthalate, monocyclohexyl
 isophthalate and or dicyclohexyl isophthalate.

37. A process as claimed in any one of claims 1 to 30 wherein the one or
 more benzenecarboxylic acid derivatives are one or more terephthalates
 selected from the group consisting of monomethyl terephthalate, dimethyl
 terephthalate, diethyl terephthalate, di-n-propyl terephthalate, di-n-butyl
 terephthalate, di-tert-butyl terephthalate, diisobutyl terephthalate,
 monoglycol esters of terephthalic acid, diglycol esters of terephthalic acid,
 di-n-octyl terephthalate, diisooctyl terephthalate, mono-2-ethylhexyl
 terephthalate, di-2-ethylhexyl terephthalate, di-n-nonyl terephthalate,
 diisononyl terephthalate, di-n-decyl terephthalate, di-n-undecyl
 terephthalate, diisodecyl terephthalate, diisoundecyl terephthalate,
 diisododecyl terephthalate, di-n-octadecyl terephthalate, diisooctadecyl
 terephthalate, di-n-eicosyl terephthalate, ditridecyl terephthalate,

diisotridecyl terephthalate, monocyclohexyl terephthalate and or dicyclohexyl terephthalate.

38. A process as claimed in any one of claims 1 to 30 wherein the one or more benzenecarboxylic acid derivatives are one or more alkyl trimellitates selected from the group consisting of such as monomethyl trimellitate, dimethyl trimellitate, diethyl trimellitate, di-n-propyl trimellitate, di-n-butyl trimellitate, di-tert-butyl trimellitate, diisobutyl trimellitate, the monoglycol ester of trimellitic acid, diglycol esters of trimellitic acid, di-n-octyl trimellitate, diisooctyl trimellitate, di-2-ethylhexyl trimellitate, di-n-nonyl trimellitate, diisononyl trimellitate, di-n-decyl trimellitate, diisodecyl trimellitate, di-n-undecyl trimellitate, diisoundecyl trimellitate, diisododecyl trimellitate, di-n-octadecyl trimellitate, diisooctadecyl trimellitate, di-n-eicosyl trimellitate, monocyclohexyl trimellitate, dicyclohexyl trimellitate and trimethyl trimellitate, triethyl trimellitate, tri-n-propyl trimellitate, tri-n-butyl trimellitate, tri-tert-butyl trimellitate, triisobutyl trimellitate, triglycol esters of trimellitic acid, tri-n-octyl trimellitate, triisooctyl trimellitate, tri-2-ethylhexyl trimellitate, tri-n-nonyl trimellitate, tri-isononyl trimellitate, tri-n-decyl trimellitate, triisododecyl trimellitate, tri-n-undecyl trimellitate, tri-isoundecyl trimellitate, triisododecyl trimellitate, tri-n-octadecyl trimellitate, triisooctadecyl trimellitate, tri-n-eicosyl trimellitate and tricyclohexyl trimellitate.

39. A process as claimed in any one of claims 1 to 30 wherein the one or more benzenecarboxylic acid derivatives are one or more alkyl trimesates selected from the group consisting of monomethyl trimesate, dimethyl trimesate, diethyl trimesate, di-n-propyl trimesate, di-n-butyl trimesate, di-tert-butyl trimesate, diisobutyl trimesate, monoglycol esters of trimesic acid, diglycol esters of trimesic acid, di-n-octyl trimesate, diisooctyl trimesate, di-2-ethylhexyl trimesate, di-n-nonyl trimesate, diisononyl

- trimesate, di-n-decyl trimesate, diisodecyl trimesate, di-n-undecyl
trimesate, di-isoundecyl trimesate, diisododecyl trimesate, di-n-octadecyl
trimesate, diisooctadecyl trimesate, di-n-eicosyl trimesate,
monocyclohexyl trimesate, dicyclohexyl trimesate, and also trimethyl
5 trimesate, triethyl trimesate, tri-n-propyl trimesate, tri-n-butyl trimesate,
tri-tert-butyl trimesate, triisobutyl trimesate, triglycol esters of trimesic
acid, tri-n-octyl trimesate, triisooctyl trimesate, tri-2-ethyl-hexyl trimesate,
tri-n-nonyl trimesate, tri-isononyl trimesate, tri-n-decyl trimesate,
triisododecyl trimesate, tri-n-undecyl trimesate, tri-isoundecyl trimesate,
10 triisododecyl trimesate, tri-n-octadecyl trimesate, triisooctadecyl
trimesate, tri-n-eicosyl trimesate and tricyclohexyl trimesate.
40. A process as claimed in any one of claims 1 to 30 wherein the one or
more benzenecarboxylic acid derivates are one or more alkyl
15 hemimellitates selected from the group consisting of monomethyl
hemimellitate, dimethyl hemimellitate, diethyl hemimellitate, di-n-propyl
hemimellitate, di-n-butyl hemimellitate, di-tert-butyl hemimellitate,
diisobutyl hemimellitate, monoglycol esters of hemimellitic acid, diglycol
esters of hemimellitic acid, di-n-octyl hemimellitate, diisooctyl
20 hemimellitate, di-2-ethylhexyl hemimellitate, di-n-nonyl hemimellitate,
diisononyl hemimellitate, di-n-decyl hemimellitate, diisodecyl
hemimellitate, di-n-undecyl hemimellitate, di-isoundecyl hemimellitate,
diisododecyl hemimellitate, di-n-octadecyl hemimellitate, diisooctadecyl
hemimellitate, di-n-eicosyl hemimellitate, monocyclohexyl hemimellitate,
25 dicyclohexyl hemimellitate, and also trimethyl hemimellitate, triethyl
hemimellitate, tri-n-propyl hemimellitate, tri-n-butyl hemimellitate, tri-
tert-butyl hemimellitate, triisobutyl hemimellitate, triglycol esters of
hemimellitic acid, tri-n-octyl hemimellitate, triisooctyl hemimellitate, tri-
2-ethylhexyl hemimellitate, tri-n-nonyl hemimellitate, tri-isononyl
30 hemimellitate, tri-n-decyl hemimellitate, triisodecyl hemimellitate, tri-n-
undecyl hemimellitate, tri-isoundecyl hemimellitate, triisododecyl

hemimellitate, tri-n-octadecyl hemimellitate, triisooctadecyl hemimellitate, tri-n-eicosyl hemimellitate and tricyclohexyl hemimellitate.

- 5 41. A process as claimed in any one of claims 1 to 30 wherein the one or more benzenecarboxylic acid derivatives are one or more alkyl pyromellitates selected from the group consisting of monomethyl pyromellitate, dimethyl pyromellitate, diethyl pyromellitate, di-n-propyl pyromellitate, di-n-butyl pyromellitate, di-tert-butyl pyromellitate, 10 diisobutyl pyromellitate, monoglycol esters of pyromellitic acid, diglycol esters of pyromellitic acid, di-n-octyl pyromellitate, diisooctyl pyromellitate, di-2-ethylhexyl pyromellitate, di-n-nonyl pyromellitate, diisononyl pyromellitate, di-n-decyl pyromellitate, diisodecyl pyromellitate, di-n-undecyl pyromellitate, di-isoundecyl pyromellitate, 15 diisododecyl pyromellitate, di-n-octadecyl pyromellitate, diisooctadecyl pyromellitate, di-n-eicosyl pyromellitate, monocyclohexyl pyromellitate, trimethyl pyromellitate, triethyl pyromellitate, tri-n-propyl pyromellitate, tri-n-butyl pyromellitate, tri-tert-butyl pyromellitate, triisobutyl pyromellitate, triglycol esters of pyromellitic acid, tri-n-octyl 20 pyromellitate, triisooctyl pyromellitate, tri-2-ethylhexyl pyromellitate, tri-n-nonyl pyromellitate, tri-isononyl pyromellitate, triisodecyl pyromellitate, tri-n-decyl pyromellitate, tri-n-undecyl pyromellitate, tri-isoundecyl pyromellitate, triisododecyl pyromellitate, tri-n-octadecyl pyromellitate, triisooctadecyl pyromellitate, tri-n-eicosyl pyromellitate, 25 tricyclohexyl pyromellitate, and also tetramethyl pyromellitate, tetraethyl pyromellitate, tetra-n-propyl pyromellitate, tetra-n-butyl pyromellitate, tetra-tert-butyl pyromellitate, tetraisobutyl pyromellitate, tetraglycol esters of pyromellitic acid, tetra-n-octyl pyromellitate, tetraisooctyl pyromellitate, tetra-2-ethylhexyl pyromellitate, tetra-n-nonyl 30 pyromellitate, tetraisododecyl pyromellitate, tetra-n-undecyl pyromellitate, tetraisododecyl pyromellitate, tetra-n-octadecyl

pyromellitate, tetraisooctadecyl pyromellitate, tetra-n-eicosyl
pyromellitate, tetracyclohexyl pyromellitate.

5 42. A process as claimed in any one of claims 1 to 30 wherein the one or
more benzenecarboxylic acid derivates are one or more alkyl
terephthalates, alkyl phthalates, alkyl isophthalates, dialkyl or trialkyl
trimellitates, dialkyl or trialkyl trimesates, dialkyl or trialkyl
hemimellitates, or dialkyl, trialkyl or tetraalkyl pyromellitates, in which
one or more of the alkyl groups contain 5, 6 or 7 carbon atoms.

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43. A process as claimed in claim 42 wherein the one or more alkyl groups
containing 5, 6 or 7 carbon atoms are selected from the group consisting
of n-pentyl, 1-methylbutyl terephthalate, 2-methylbutyl, 3-methylbutyl,
2,2-dimethylpropyl, 1,1-dimethylpropyl, n-hexyl, 1-methylpentyl, 2-
15 methylpentyl, 3-methylpentyl, 4-methylpentyl, 1,1-dimethylbutyl, 2,2-
dimethylbutyl, 3,3-dimethylbutyl, 1,2-dimethylbutyl, 1,3-dimethylbutyl,
2,3-dimethylbutyl, 1-methyl-2-ethylpropyl, 1-ethyl-2-methylpropyl, 1-
ethylbutyl, 2-ethylbutyl, n-heptyl, 1-methylhexyl, 2-methylhexyl, 3-
methylhexyl, 4-methylhexyl, 5-methylhexyl, 1,1-dimethylpentyl, 2,2-
20 dimethylpentyl, 3,3-dimethylpentyl, 4,4-dimethylpentyl, 1-ethylpentyl, 2-
ethylpentyl, 3-ethylpentyl, 1,1,2-trimethylbutyl, 1,1,3-trimethylbutyl,
1,2,2-trimethylbutyl, 2,2,3-trimethylbutyl, 1,3,3-trimethylbutyl, 2,3,3-
trimethylbutyl, 1,2,3-trimethylbutyl, 1-ethyl-2-methylbutyl, 1-ethyl-3-
methylbutyl, 2-ethyl-3-methylbutyl and 1-methyl-2-ethylbutyl.

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44. A process as claimed in any one of claims 1 to 30 wherein the one or
more benzenecarboxylic acid derivates are one or more alkyl
terephthalates, alkyl phthalates, alkyl isophthalates, dialkyl or trialkyl
trimellitates, dialkyl or trialkyl trimesates, dialkyl or trialkyl
30 hemimellitates, or dialkyl, trialkyl or tetraalkyl pyromellitates, in which at

least one of the alkyl groups are isononyl and derived from either n-butene or isobutene.

5 45. A process as claimed in any one of the preceding claims, wherein the hydrogenation is carried out in the presence of a solvent or diluent.

46. A process as claimed in any one of the preceding claims, wherein the hydrogenation is carried out continuously.

10 47. A process as claimed in any one of the preceding claims wherein the hydrogenation process is carried out at a pressure of 25 to 70 bar.

15 48. A process as claimed in any one of claims 1 to 30 wherein the hydrogenation process is carried out at a pressure of 20 to 300 bar.

49. A cyclohexanepolycarboxylic acid or derivative thereof obtainable from a hydrogenation process as claimed in any one of the preceding claims.

20 50. A cyclohexanepolycarboxylic acid ester obtainable from a hydrogenation process as claimed in any one of claims 1 to 47.

51. A cyclohexanepolycarboxylic acid anhydride obtainable from a hydrogenation process as claimed in any one of claims 1 to 47.

25 52. A composition comprising at least one plastic and one or more cyclohexanepolycarboxylic acids or derivatives thereof as claimed in any one of claims 49 to 51.